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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 09/894,230
Filing Date: June 27, 2001
Appellant(s): KO ET AL.

Michael L. Glencarella
For Appellant

EXAMINER'S ANSWER

MAILED
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GROUP 1700

This is in response to the appeal brief filed June 23, 2005 appealing from the Office action mailed August 24, 2004.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings, which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

No amendment after final has been filed.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is deficient. 37 CFR 41.37(c)(1)(v) requires the summary of claimed subject matter to include: (1) a concise explanation of the subject matter defined in each of the independent claims involved in the appeal, referring to the specification by page and line number, and to the drawing, if any, by reference characters and (2) for each independent claim involved in the appeal and for each dependent claim argued separately, every means plus function and step plus function as permitted by 35 U.S.C. 112, sixth paragraph, must be identified and the structure, material, or

acts described in the specification as corresponding to each claimed function must be set forth with reference to the specification by page and line number, and to the drawing, if any, by reference characters.

The brief is deficient in this regard because it includes extraneous unclaimed subject matter along with that from instant dependent claims under this section heading. For instance, none of the instant appealed claims specifically recite (i) an underlying interlayer dielectric (ILD), (ii) dual damascene patterning, or (iii) combining fabrication steps into a single system (or apparatus), all of which are found in the first full paragraph on page 2 of the brief.

(6) Grounds of Rejection to be Reviewed on Appeal

The Appellants' statement of the grounds of rejection to be reviewed on appeal is basically correct in summary form, but for the purpose of convenience these grounds of rejection over the prior art of record in the final rejection mailed on August 24, 2004 are fully represented as shown below.

A. Claims 16-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163) in view of Young et al. (US Patent 6,255,022) and further in view of Schroeder et al. (US Patent 6,379,869).

Sato teaches a process for improving etching resistance (increasing selectivity) of an organosilicon photoresist by first energy beam imaging of the photoresist with or without post-exposure baking, developing, then second energy beam post-treatment (exposing) of the imaged

photoresist (column 97, lines 42-54). Column 5, lines 6-7 show alternative use of a charged beam (electron or ion beam specified at column 3, lines 59-61) as the first energy beam and ultraviolet (UV) rays as the second energy beam. The second energy beam (UV) exposure cross-links organosilicon polymer in the imaged photoresist to form a hardened etching mask having improved resistance to subsequent etching (column 82, lines 15-18 and column 96, lines 56-64). Specific examples of organosilicon compounds useful in the photoresist are polysilane and polysilene shown by formulas [1-1] to [1-114] in columns 6-28, but particular attention is drawn to those showing Si-H and Si-CH_3 bonds, such as those in formulas [1-14] to [1-16] found in column 8 (instant claim 17 interpreted only as disclosed in the last line of instant page 11). The organosilicon photoresist containing an organosilicon compound can be selectively hardened with a charged beam by conversion into a silicon oxide/carbide-like film in order to improve etching resistance for use as an etching mask. Alternatively, the organosilicon photoresist may be used as an underlying layer that also functions as an antireflective film during exposure of an overlying top resist (column 4, lines 4-21, column 5, lines 25-67, and column 96, line 64 to column 97, line 4). The organosilicon photoresist can also contain a cross-linking agent for curing/hardening the organosilicon compound to provide increased solvent and heat resistance, as well as improving etching resistance for use as an etching mask (column 28, line 65 to column 29, line 1 and column 96, lines 56-63). Examples of cross-linking agents having multiple (double or triple) bonds are shown by formulas [3-1] to [3-88] in columns 61-72 and are described as reacting at Si-H bonds to cross-link the organosilicon polymer under the effect of heat or light at column 61, line 50 to column 62, line 51. Other examples of cross-linking agents are described at column 82, line 1 to column 96, line 55. The overlying top resist is not

particularly limited (e.g., the top resist does not have to contain an organosilicon compound (non-organosilicon resist), the top resist can be selected according to the particular end use as either a positive or a negative resist, etc., column 97, lines 5-29). Example 1 shows coating of a SiO_2 work film 11 on a silicon wafer 10, adding an underlying film having an organosilicon compound 12, and overcoating the underlying film with a resist 13 as shown in Figure 1A. The resist is baked, exposed by KrF excimer laser, baked again, then developed to form a line-and-space pattern 14 as shown in Figure 1B. An accelerating voltage of 1.8 kV was used to project an electron beam 15 on the resist pattern 14 for detecting the position of the resist pattern. A separate electron beam at a much stronger accelerating voltage of 10 kV was then used to expose and harden at least upper regions 16 at portions of the organosilicon underlying film 12 as shown in Figure 1C. Then, the resist pattern 14 and electron beam regions 16 of the underlying film are used as etching masks for dry etching of the unexposed/unhardened regions of the underlying film to form an underlying film pattern portion 17 using the resist pattern 14 as an etching mask and another underlying film pattern portion 18 using the hardened regions 16 as an etching mask as shown in Figure 1D. Both of these etching masks provided excellent anisotropic etching of the unhardened/unexposed regions of the underlying film. The unhardened organosilicon underlying film was more selectively etched than either the overlying resist pattern 14 or the electron beam hardened regions 16 of the organosilicon underlying film. The previous electron beam exposure of at least the top regions 16 of the organosilicon underlying film resulted in conversion of the organosilicon compound to oxide/carbide silicon-like film regions, which are much harder to etch than the unexposed regions of the organosilicon underlying film. It is also noted that while comparison of Figures 1C and 1D suggests a reduction in thickness of the

patterned upper resist 14 during etching, no such reduction in thickness is apparent for the electron beam hardened organosilicon regions 16. This suggests that the hardened organosilicon regions present greater resistance to subsequent etching than does the non-organosilicon resist 14 (column 99, line 25 to column 102, line 30). Example 5 shows an alternative embodiment in which the underlayer is a non-organosilicon antireflective layer 72 between the work film 71 to be etched and an overlying resist film 73, as shown in Figure 5A. In this case, electron beam exposure 75 of the overlying resist film comes first, followed by baking, developing, and helium neon laser detecting of the first resist pattern. KrF excimer laser exposure 80 of additional regions of the remaining overlying resist comes next, then further baking and developing to form patterns 76 and 81 as shown in Figures 5B-5E (column 170, line 17 to column 108, line 8). This latter example lays out a potential use for a non-organosilicon underlayer in a similar process that involves similar patterning of an overlying resist (which could be an organosilicon photoresist) before etching of an underlying layer.

Sato does not specifically require: (1) that the organosilicon photoresist be formed and patterned over the non-organosilicon resist before selective etching of an underlying layer nor (2) that the organosilicon photoresist be subsequently exposed to UV light after being imaged and developed.

Young teaches a bi-layer resist process for improving dimension control during subsequent etching of an underlying substrate (column 1, lines 8-11). A first underlayer of resist 18 (e.g., acrylic polymer (non-organosilicon), etc.) is coated on a substrate and this underlayer is baked (Figure 2, column 2, lines 53-60). The first resist underlayer 18 is covered by a second resist layer 20 (e.g., silicon-containing monomer (organosilicon), etc.), which is also baked

(Figure 3, column 2, lines 61-67). If the second resist 20 does not yet contain silicon as deposited, then the resist 20 would be silylated to make it resistant to subsequent dry etching (e.g., oxygen reactive ion etching (RIE), etc.). During silylation, silicon atoms would displace hydrogen-containing radicals in the resist 20 (column 3, lines 1-13). Top silicon containing resist 20 is exposed to actinic light through a patterned mask 22 (Figure 4, column 3, lines 14-16) and then developed (Figure 5, column 3, lines 17-20). Next, the non-organosilicon resist underlayer 18 is oxygen dry etched through the patterned silicon containing resist 20, which blocks the dry etchant to protect underlying portions of the resist 18 during etching (Figure 6, column 3, lines 21-24). This etching step is also called dry development and results in conversion of the remaining top resist 20 to silicon dioxide (conversion of the silicon containing top portion of the bi-layer resist to oxide, column 3, lines 46-48). This oxide conversion hardens the top silicon containing resist 20 against subsequent oxygen ashing (column 3, lines 56-64) and etching as shown in Figure 7 (column 4, lines 1-5).

Schroeder teaches a method of improving etch resistance while maintaining radiation sensitivity of a patterned (exposed and developed) resist by introducing silicon into the top and side portions of the developed resist pattern (column 1, line 60 to column 2, line 10). The resist may be either a positive or a negative resist and imaging of the resist is by actinic radiation (e.g., UV radiation, x-ray, electron beam, etc., column 2, lines 37-43). After patterning by imaging and developing, the resist is deprotected by deep UV flood exposure to expose active sites of the resist base resin to prepare it for subsequent reaction with an etch protectant, followed by baking or heating (column 4, lines 6-11). Next, the developed and deprotected resist is treated with an etching protectant, which includes a silylating agent for bonding to the resist base resin. The

silylating agent provides increased etching resistance by contributing silicon to the resist structure (column 4, lines 28-42). Silylated top and side surface regions 4 are shown on the developed resist pattern 3 in Figure 3. These silicon containing surface regions 4 possess greater etching resistance than do unmodified non-silicon containing regions (column 4, lines 43-46). These silicon containing top regions are particularly advantageous for imparting etching resistance against oxygen plasma during subsequent etching through the resist. The etching rate of these silicon containing top regions is less that 45% of that for the non-silicon containing resist portions. This allows a silicon containing resist having hardened top portions to be formed into thinner layers to produce sharper images (column 4, line 63 to column 5, line 4).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to have reversed the order of the non-organosilicon resist and the organosilicon photoresist as taught by Sato so that the underlying layer was the non-organosilicon resist and the top layer was the organosilicon photoresist as taught by Young. This is because both resist layers are patterned by radiation (e.g., UV, electron beam, etc.) imaging and the overall etching resistance of a bi-layer resist etching mask for improved selectivity is a combination of the etching resistance of both layers when added together, regardless of order. However, the silicon containing resist, as the stronger etching mask, should logically be the first line of defense as the top resist layer over an underlying non-silicon containing resist, as the weaker etching mask, in protecting the non-etched areas of the underlying substrate or work film from overetching. Both Young and Schroeder choose this configuration. It would also have been obvious to subsequently expose the developed top portion of the silicon containing resist as taught by Schroeder to convert it into a hardened layer for improving etching resistance. Sato, Young, and

Schroeder all relate to the same art of hardening a silicon containing resist for improving etching selectivity and resistance of the resist during subsequent etching.

B. Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163) in view of Young et al. (US Patent 6,255,022), further in view of Schroeder et al. (US Patent 6,379,869), and further in view of Tsai et al. (US Patent 5,899,748).

While showing UV exposure of a developed organosilicon photoresist image to cross-link and harden the photoresist layer followed by subsequent etching through the hardened photoresist layer, Sato, Young, and Schroeder do not specify that the UV exposure should be conducted in an etching chamber.

Tsai specifies UV exposure of a photoresist layer in an etching chamber that provides UV emission and implies the advantage of simplified processing over UV exposure and etching in separate chambers (which would require taking the photoresist layer off-line for UV treatment before returning the photoresist layer to the etching chamber described at column 6, lines 30-39).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to expose the photoresist to UV hardening as taught by Sato, Young, and Schroeder in an etching chamber that provides UV emission prior to etching with the expectation of simplifying processing (by avoiding taking the photoresist to a separate UV chamber before returning the photoresist to the etching chamber) as taught by Tsai.

C. Claims 19-23 and 37-39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163) in view of Young et al. (US Patent 6,255,022), further in view of

Schroeder et al. (US Patent 6,379,869), further in view of Tsai et al. (US Patent 5,899,748), further in view of Kishimura (US Patent 5,123,998), further in view of Singh et al. (US Patent 6,479,820), and further in view of George et al. (US Patent 4,980,563).

Sato, Young, Schroeder, and Tsai do not specify use of argon (Ar) inert gas flowing to the etching chamber at about 1000 to 3000 sccm during UV exposure generated by neon (Ne) gas and do not specify that the flow rate of Ne must be about 0.2% to 0.8% of the flow rate of Ar. Also, Sato, Young, Schroeder, and Tsai do not require striking plasma composed of Ar and Ne gases to generate UV in the etching chamber.

Kishimura teaches UV imaging (exposing) of a photoresist in inert gas (e.g., Ne, Ar, He, N_2, etc., column 10, lines 5-9) for more efficient cross-linking of the photoresist by UV exposure (column 5, lines 58-68), selective silylation to incorporate silicon (Si) into the photoresist by forming Si-CH_3 bonds (shown in Figure 2B) with the unexposed areas of the photoresist (column 6, lines 21-25), followed by developing and dry etching by O_2 reactive ion etching (RIE) to convert the silylated regions of the photoresist to SiO_2 as a powerful shielding material to O_2 plasma, allowing only the exposed regions to be removed by etching (column 6, lines 26-31).

Singh describes plasma post-treatment of a developed photoresist image in which the plasma includes one or more inert gases (e.g., Ar, Ne, He, Ne, Kr, Xe, etc.) flowing at 10 sccm to 10 slm (10,000 sccm) under a pressure of 0.0001 to 1,000 Torr to ionize and maintain the inert gas in a plasma state at column 6, lines 7-23. Any suitable temperature can be used for generating ions in the plasma (e.g., about 25 °C to about 1400 °C, etc., column 6, lines 25-30).

George shows a UV lithography process and apparatus using a UV source gas (e.g., Ne for 85 nm, He for 65 nm, Ar for 130 nm, krypton (Kr) for 150 nm, xenon (Xe) for 170 nm, etc.)

at column 3, lines 22-32. Ar, Kr, Xe, or other suitable gas or mixture is placed on a cold plate or heat exchanger. The cold plate is cryogenically cooled (e.g., maintained at a temperature of about 77 °K by liquid nitrogen or about 20 °K by gaseous helium refrigeration, etc.). UV radiation is produced with high conversion efficiency to UV of about 50 Percent (column 3, lines 33-50).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the UV hardening exposure of a developed photoresist in an etching chamber that provides UV emission and etching using the hardened photoresist in the same chamber as taught by Sato, Young, Schroeder, and Tsai with Ar inert gas flow to the etching chamber during UV hardening at a flow rate of 10 to 10,000 sccm as taught by Singh (encompassing the Ar inert gas flow rate of about 1,000 to 3,000 sccm in instant claims 19-20) for more efficient cross-linking of the photoresist by the UV exposure as shown by Kishimura. It would also have been obvious to control inert gas pressure at 0.0001 to 1,000 Torr for any suitable temperature (e.g., about 25 °C to about 1400 °C, etc., which approaches and reads on the 0 °C of instant claim 38, especially given the wide range of suitable pressures and temperatures) in the etching chamber during plasma post-treatment (UV exposure) of the developed photoresist image as shown by Singh to strike and maintain the inert gas plasma in the etching chamber as described by Singh (instant claim 37). During UV generation from a suitable source gas or mixture thereof, colder temperatures than the exemplary range shown by Singh, extending even down to 20 ° K or 77 °K (-253 °C or -196 °C, respectively) would have been expected to produce the UV at a high conversion efficiency, as shown by George (encompassing the 0 °C of instant claim 38).

It would also have been obvious to one of ordinary skill in the art at the time the invention was made to combine the UV exposure hardening of developed photoresist and etching taught by Sato, Young, Schroeder, and Tsai with a UV generation source having (1) Ne gas (instant claims 21 and 39) to obtain an 85 nm emission or (2) a mixture of Ne and Ar (such as that obtained by a flow rate of Ne between about 0.2% and 0.8% of the flow rate of Ar, instant claim 22) to obtain an emission between 85 nm and 130 nm (UV light) as shown by George.

D. Claim 24 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163) in view of Young et al. (US Patent 6,255,022), further in view of Schroeder et al. (US Patent 6,379,869), and further in view of Rangarajan et al. (US Patent 6,451,512).

While clearly showing conversion of at least the top portions of regions of an organosilicon photoresist, Sato, Young, and Schroeder do not specify that these top portions be limited to 5% to 75% conversion of the developed organosilicon photoresist to a hardened layer before etching using the hardened layer.

Rangarajan teaches post-developing photoresist silylation in UV to enhance incorporation of silicon (Si) and cross-linking of the resulting organosilicon polymer in the photoresist for increased etching resistance (selectivity) at column 3, lines 14-26, column 4, line 66 to column 5, line 4, column 5, lines 14-42, 58-62, and column 7, lines 51-55. Column 6, lines 58-61 shows use of an inert gas (e.g., Ne, Ar, He, etc.) during the UV treatment. Si atoms are incorporated into the photoresist during UV hardening to a depth of between 2% and 100% of the photoresist thickness (column 10, lines 47-52).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the UV hardening of Sato as discussed above in order to harden the top 2% to 100% of the developed organosilicon photoresist layer (encompassing the 5% to 75% hardening of instant claim 24) to improve the etching resistance (selectivity) of the organosilicon photoresist layer as shown by Rangarajan.

(7) Response to Arguments

A. Claims 16-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163) in view of Young et al. (US Patent 6,255,022) and further in view of Schroeder et al. (US Patent 6,379,869).

In response to Appellants' arguments against the references individually, one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.*, 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986).

On pages 4-6 of the brief, Appellants have argued against Sato alone, including statements on pages 5-6 that the inclusion of aligning multiple resist patterns in Sato makes this reference less applicable to instant claims 16-17, which do not require such alignment. However, the open "comprising" language of instant claim 16 reads on additional steps not specifically recited and permits the application of references that teach such additional steps (e.g., as taught by Sato, etc.). Furthermore, the above art rejection does not rely on Sato alone, but rather on the combination of Sato, Young et al., and Schroeder et al. The reasons for combining each of these references have been detailed in the previous Office actions of record

and have again been set forth above. Specifically, both Young et al. and Schroeder et al. show the well-known desirability of choosing a top resist that either (1) contains silicon before patterned exposure and developing or (2) can be silylated after exposure and developing of a pattern; in order to harden the top resist to subsequent etching.

Sato does not dispute the well-known desirability of incorporating silicon into an exposed or hardened resist pattern to improve resistance to subsequent etching. In fact, as previously pointed out, it is noted that comparison of Sato's Figure 1C (before etching) and Figure 1D (after etching) shows the well-known reduction in thickness of the non-organosilicon patterned resist 14 during etching, but the hardened organosilicon resist regions 16 do not suffer any notable reduction in thickness during this same etching step (which is consistent with the well-known better etching resistance of a hardened organosilicon resist over that of a developed non-organosilicon resist). While Sato's description of Figures 1C and 1D (column 97 line 49 to column 98 line 12 and column 101 lines 45-53) does not elaborate on this point, it is still believed that the differences shown by these figures would confirm to one of ordinary skill in the art that the hardened organosilicon resist pattern has a greater etching resistance than that of the overlying non-organosilicon developed resist pattern. Appellants have attempted to refute this well-known difference in etching resistance between the hardened organosilicon and non-organosilicon resist patterns by asserting at page 6 lines 10-11 of the brief that "both are equally excellent (See column 102 lines 11-22)". But this passage of Sato actually only states that both the hardened organosilicon pattern 16 etching mask and the developed non-organosilicon resist pattern 14 etching mask "were both excellent ***in anisotropy***" (column 102 line 15, emphasis added), without negating or teaching away from the well-known difference in etching resistance

between these two etching masks that is confirmed by a comparison of Figures 1C (before etching) and 1D (after etching).

Appellants also state at page 6 lines 20-21 of the brief that Sato's hardened organosilicon resist pattern was formed by exposure to a charged beam (as the second energy beam), not ultraviolet (UV) light. While describing UV light for the first energy beam used to pattern the top non-organosilicon resist layer 13 in Figure 1A and a charged beam as the second energy beam for hardening top portions 16 of the underlying organosilicon resist 12 in Figure 1D (column 97 lines 6-51), Sato also specifically contemplates the alternative use of a charged beam as the first energy beam and UV rays as the second energy beam (column 98 lines 37-41). Sato teaches the additional use of a cross-linking agent in the organosilicon resist that functions to cross-link and harden the organosilicon resist by the effect of either heat or light (column 61 line 50 to column 62 line 51). Thus, the organosilicon resist taught by Sato is cross-linked and hardened by either a charged beam or UV light.

In response to Appellants' argument on pages 6-7 of the brief that Young et al. and Schroeder et al. cannot be combined with Sato, the fact that Appellants have recognized another advantage, which would flow naturally from following the suggestion of the prior art, cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

On page 7 of the brief, Appellants state that Sato teaches the silicon-silicon bonds of the organosilicon resist are highly etchable and therefore best suited for the bottom resist layer. However, this greater etchability only applies to the portions of the organosilicon resist 12 that remain unprotected by an overlying hardened top region, not for those portions that are protected

by overlying hardened or cross-linked organosilicon resist portions 16 (see Sato's Figures 1C and 1D), which are actually highly etch resistant. This difference in etchability allows excellent anisotropic etching through the hardened or cross-linked organosilicon resist portions 16 as an etching mask. Appellants also assert that reversing the order of Sato's bottom hardened organosilicon resist pattern and top developed non-organosilicon resist pattern as taught by Young et al. so that the hardened organosilicon resist pattern is on top of the non-organosilicon resist pattern would necessarily result in isotropic etching of the underlying layer. However, Sato's top developed non-organosilicon resist pattern also allows excellent anisotropic etching, so there is no reason to believe that placing Sato's hardened organosilicon resist pattern on top of the developed non-organosilicon resist pattern, which is the order taught by Young et al., would result in anything other than anisotropic etching of the underlayer. This latter configuration of the hardened organosilicon resist as the stronger etching mask on top of the developed non-organosilicon resist pattern as the weaker etching mask would be expected to provide better protection of the developed non-organosilicon resist pattern from reduced thickness during etching as suggested by Sato's Figures 1C and 1D that would occur if the non-organosilicon resist pattern were not so protected during subsequent etching.

In response to Appellants' argument on page 7 that the post development UV treatment to harden top portions of a resist pattern to promote silylation taught by Schroeder et al. in combination with the teachings of Sato and Young et al. does not amount to UV post-treatment to harden an organosilicon resist, the test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference(s); nor is it that the claimed invention must be expressly suggested in any one or all of the

references. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981). Contrary to Appellants' argument, Sato teaches UV hardening of top portions of an organosilicon resist (as discussed above). Young et al. teach a bilayer resist process using a bottom resist and an overlying top resist pattern (as a stronger etching mask than that of the bottom resist) made either from an organosilicon resist that has been patterned or an alternative non-organosilicon resist that has been patterned and then treated by subsequent silylation to add silicon for improving etching resistance (also discussed above). Schroeder et al. teach post-treatment UV exposure of a patterned resist for silylation to harden the top portion of the patterned resist after developing (further discussed above). Therefore, it would have been obvious to one of ordinary skill in the art to use Sato's organosilicon resist on top of a non-organosilicon resist in the well-known bilayer configuration taught by either Young et al. or Schroeder et al., followed by patterning and post-treatment UV exposure of at least the upper portion of the top resist pattern (as shown by Sato and Schroeder et al.) to achieve greater etching resistance and selectivity of the bilayer resist pattern as an etching mask and allow the silicon containing top resist having hardened top portions to be formed into thinner layers to produce sharper images (as taught by Schroeder et al.).

In response to Appellants' arguments on page 8 of the brief that there is no suggestion to combine the references, the Examiner recognizes that obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. See *In re*

Fine, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988) and *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). In this case, the reasons for combining the references have been previously set forth.

In summary, Appellants charge on page 8 of the brief that the Examiner has failed to consider each reference in its entirety (MPEP 2141), but without any additional specific reason not presented earlier. Nevertheless, it is still believed that the MPEP 2141.2 requirement for considering each reference in its entirety has been met above in answering each argument specifically raised by Appellants in their brief against the rejection of claims 16-17.

Therefore, the instant claims are still believed to be obvious in view of the prior art, for at least the reasons set forth above.

B. Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163) in view of Young et al. (US Patent 6,255,022), further in view of Schroeder et al. (US Patent 6,379,869), and further in view of Tsai et al. (US Patent 5,899,748).

Appellants begin the last paragraph at the bottom of page 8 and complete this paragraph at the top of page 9 of the brief by arguing against the combination of all four references cited in the applicable rejection set forth above, but when actually specifying alleged deficiencies in this rejection, they only argue against the combination of Sato and Tsai et al. alone, without the benefit of either Young et al. or Schroeder et al. Thus, Appellants are arguing that Tsai et al. alone does not cure all the deficiencies of Sato, per se, but such a rejection of claim 18 over only Sato and Tsai et al. has not been proposed in the rejection of claim 18 over Sato, Young et al., Schroeder et al., and Tsai et al., as set forth in prior Office actions and again repeated above.

In response to Appellants' arguments against the references individually (or as a subset of only Sato and Tsai et al.), one cannot show nonobviousness by attacking references individually (or as a subset of only Sato and Tsai et al.) where the rejections are based on combinations of references (as a set of all four combined references including Young et al. and Schroeder et al. along with Sato and Tsai et al.). See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.*, 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986).

Additionally, Appellants assert on page 9 of the brief that Sato, Young et al., and Schroeder et al. each require baking and developing of the exposed resist and that using the etching chamber of Tsai et al. to expose the undeveloped resist of Sato, Young et al., and Schroeder et al. would do nothing for the simplification of processing, because the etching chamber must accommodate exposing, baking, and developing, as well as silylating the resist.

First, Appellants do not specify where they find support in each of the prior art references for any of these assertions. While baking or heating a resist either before exposure, after exposure and before developing, or even after developing are all well known in the art of resist processes, such baking or heating are not always required. For instance, Sato specifically teaches that baking of the non-organosilicon resist is only carried out ***if*** required (column 97 lines 42-44, emphasis added, which has been interpreted to mean that baking is actually optional, not required as now asserted for the first time by Appellants) and Sato is believed to be silent about any necessity for baking of the organosilicon resist. Sato further teaches that developing of the unhardened portions of the exposed organosilicon resist can be done by subsequent etching (in an etching chamber).

Second, the baking of underlying non-organosilicon resist and overlying organosilicon resist taught by Young et al. is before UV exposure of the top organosilicon resist (column 2 line 52 to column 3 line 16) and the underlying non-organosilicon resist is dry developed by etching through the overlying developed and hardened organosilicon resist pattern as an etching mask (column 3 lines 46-48).

Third, the post-developing silylation and subsequent heat treatment or baking taught by Schroeder et al. (column 4 lines 6-11) would be unnecessary for an organosilicon resist that can be hardened by UV exposure against subsequent etching (e.g., as taught by Sato and Young et al., etc.).

Fourth, the rejection of claim 18 does not rely on any of these references alone or even subcombinations of only two or three of these references, but rather on all four of these references in combination (Sato, Young et al., Schroeder et al., and Tsai et al.). Therefore, it would have been obvious to one of ordinary skill in the art seeking to simplify processing that conducting UV exposure treatment (either after developing or even for patterning when dry developing by etching is used after patterned exposure) of a resist as an etching mask and subsequent etching in the same (etching) chamber, as taught by Tsai et al., would eliminate or at least reduce the need to take the resist off-line for UV treatment before returning the resist to the etching chamber (as stated in previous Office actions and repeated above).

Therefore, claim 18 is still believed to be obvious in view of the prior art, for at least the reasons set forth above.

C. Claims 19-23 and 37-39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163) in view of Young et al. (US Patent 6,255,022), further in view of Schroeder et al. (US Patent 6,379,869), further in view of Tsai et al. (US Patent 5,899,748), further in view of Kishimura (US Patent 5,123,998), further in view of Singh et al. (US Patent 6,479,820), and further in view of George et al. (US Patent 4,980,563).

In the first paragraph on page 10 of the brief, Appellants state that claims 19-23 would not be "anticipated" by the combination of Sato, Young et al., Schroeder et al, and Tsai et al. further in combination with Kishimura, Singh et al., and George et al. However, "anticipation" would require a rejection of claims 19-23 and 37-39 under 35 U.S.C. 102 over a single reference, but no such rejection has been proposed in the previous Office actions, so Appellants' argument in this regard is not applicable. Instead, these instant claims have been rejected under 35 U.S.C. 103(a) over the combination of Sato, Young et al., Schroeder et al, Tsai et al., Kishimura, Singh et al., and George et al., as previously presented and again repeated above.

Appellants' other arguments on pages 10-11 of the brief pertaining to the rejection of claims 19-23 and 37-39 refer back and repeat the previous arguments in regard to instant claims (e.g., claim 16, etc.) already discussed above under sections A. and B. Therefore, the previously discussed responses to these arguments are not repeated here avoid unnecessary duplication. Appellants also believe that the Examiner has used too many references without consideration the motivation to combine these references, but have failed to elaborate the specific motivations between these references that they consider to be lacking in the rejections of record, other than those already addressed above.

In response to Appellants' argument that the Examiner has combined an excessive number of references, reliance on a large number of references in a rejection does not, without more, weigh against the obviousness of the claimed invention. See *In re Gorman*, 933 F.2d 982, 18 USPQ2d 1885 (Fed. Cir. 1991).

In response to Appellants' argument that there is no suggestion to combine the references, the examiner recognizes that obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. See *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988) and *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). In this case, the reasons for combining Sato with Young et al., Schroeder et al., and Tsai et al. have been discussed above, both in the rejections of record and in the responses to Appellants' arguments under sections A. and B.

Furthermore, the reasons for combining Kishimura, Singh et al., and George et al. with the earlier references of Sato, Young et al., Schroeder et al., and Tsai have been specifically presented in previous Office actions. In particular, it would have been obvious to one of ordinary skill in the UV hardening exposure of a developed photoresist in an etching chamber that provides UV emission and etching using the hardened photoresist in the same chamber as taught by Sato, Young et al., Schroeder et al., and Tsai et al. to include Ar inert gas flow to the etching chamber during UV hardening at a flow rate of 10 to 10,000 sccm as taught by Singh et al. (encompassing the Ar inert gas flow rate of about 1,000 to 3,000 sccm in instant claims 19-20) for more efficient cross-linking of the photoresist by the UV exposure as shown by

Kishimura. It would also have been obvious to control inert gas pressure at 0.0001 to 1,000 Torr for any suitable temperature (e.g., about 25 °C to about 1400 °C, etc., which approaches and reads on the 0 °C of instant claim 38, especially given the wide range of suitable pressures and temperatures) in the etching chamber during plasma post-treatment (UV exposure) of the developed photoresist image as shown by Singh et al. to strike and maintain the inert gas plasma in the etching chamber as described by Singh et al. (instant claim 37). During UV generation from a suitable source gas or mixture thereof, colder temperatures than the exemplary range shown by Singh et al., extending even down to 20 ° K or 77 °K (-253 °C or -196 °C, respectively) would have been expected to produce the UV at a high conversion efficiency, as shown by George et al. (encompassing the 0 °C of instant claim 38). It would also have been obvious to one of ordinary skill in the art at the time of the invention to combine the UV exposure hardening of developed photoresist and etching taught by Sato, Young et al., Schroeder et al., and Tsai et al. with a UV generation source having (1) Ne gas (instant claims 21 and 39) to obtain an 85 nm emission or (2) a mixture of Ne and Ar (such as that obtained by a flow rate of Ne between about 0.2% and 0.8% of the flow rate of Ar, instant claim 22) to obtain an emission between 85 nm and 130 nm (UV light), as shown by George et al.

Therefore, instant claims 19-23 and 37-39 are still believed to be obvious in view of the prior art, for at least the reasons set forth above.

D. Claim 24 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163) in view of Young et al. (US Patent 6,255,022), further in view of Schroeder et al. (US Patent 6,379,869), and further in view of Rangarajan et al. (US Patent 6,451,512).

In reference to claim 24 on page 11 of the brief, Appellants argue that the actinic (UV) hardening with silylation of the top 2% to 100% of the developed resist taught by Rangarajan et al. does not resolve any of the alleged deficiencies of the combination resist process taught by Sato, Young et al., and Schroeder et al. as discussed for claims 16-17. These previously alleged deficiencies of Sato, Young et al., and Schroeder et al. have already been addressed as discussed above under sections A. and B.

Furthermore, in the resist process taught by Sato, Young et al., Schroeder et al., and Rangarajan et al., the post-developing silylation treatment taught by Schroeder et al. (column 4 lines 6-11) would be unnecessary and the simultaneous silylation with cross-linking by UV of the top 2% to 100% of the developed resist taught by Rangarajan et al. (column 3 lines 14-26, column 4 line 66 to column 5 line 4, column 5 lines 14-42, 58-62, and column 7 lines 51-55) could be simplified for an organosilicon resist that can be hardened or cross-linked in the top 2% to 100% of the organosilicon resist (against subsequent etching) by UV exposure alone (e.g., as taught by Sato and Young et al., etc.).

Therefore, claim 24 is still believed to be obvious in view of the prior art, for at least the reasons set forth above.

(8) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(9) Evidence Appendix

The brief does not list this section, but Appellants have acknowledged and relied upon the following prior art evidence of record in their appeal:

6,337,163	Sato	1-2002
6,255,022	Young et al.	7-2001
6,379,869	Schroeder et al.	4-2002
5,899,748	Tsai et al.	5-1999
5,123,998	Kishimura	6-1992
6,479,820	Singh et al.	11-2002
4,980,563	George et al.	12-1990
6,451,512	Rangarajan et al.	9-2002

(10) Related Proceedings Appendix

The brief does not list this section, but Appellants have stated under section (2) of the brief that they are not aware of any related appeals or interferences, as set forth above under section (2).

Conclusion

In their conclusion on page 12 of the brief, Appellants have repeated in summary form their prior assertions presented in subsections A, B, C, and D under section (7) Arguments. These issues have been addressed above in corresponding subsections A, B, C, and D under section (7) Response to Arguments.

For the above reasons, it is believed that the rejections should be sustained.

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Respectfully submitted,

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